June 21, 1955 W. R. KREPPS 2,710,997

METHOD OF PRODUCING BIMETAL CASTINGS

Filed June 13, 1952

Fig. 1

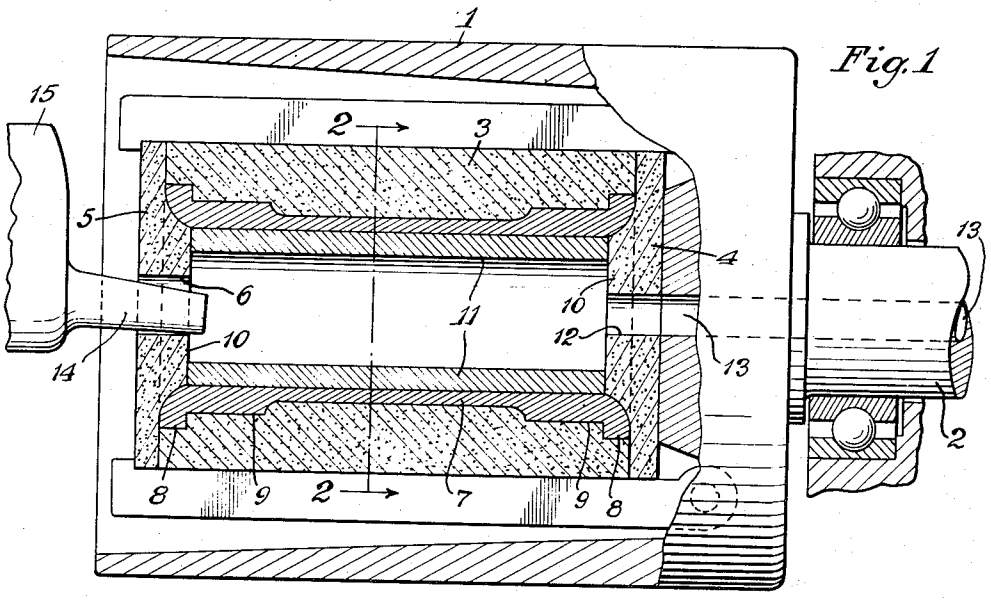


Fig. 2

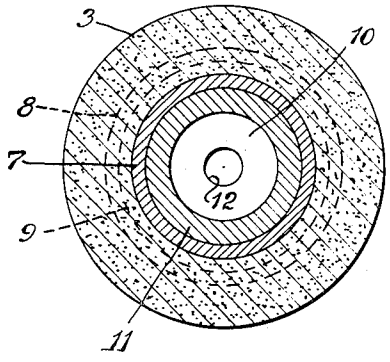


Fig. 3

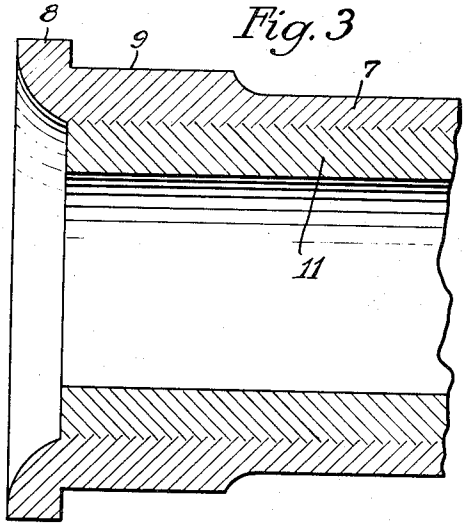
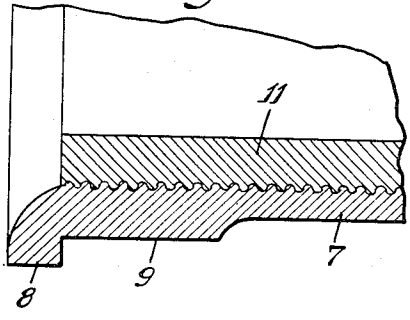


Fig. 4



Inventor
William R. Krepps
by Parker & Carter
Attorneys

United States Patent Office

2,710,997

Patented June 21, 1955

2,710,997

METHOD OF PRODUCING BIMETAL CASTINGS

William R. Krepps, Muskegon, Mich., assignor to Campbell, Wyant & Cannon Foundry Company, Muskegon Heights, Mich., a corporation of Michigan

Application June 13, 1952, Serial No. 293,377

1 Claim. (Cl. 22—200.5)

My invention relates to improvements in bimetal centrifugally cast rollers wherein a heavy, centrifugally cast steel mantle is provided with a heavy centrifugally cast iron liner, the two being, as part of the casting operation, fused together into an integral rigid whole.

One use for such rollers is as one of a plurality of rollers adapted to travel along and guide the track link treads of a track laying vehicle.

When used as a roller for a track laying vehicle, the outer steel mantle is flanged at each end, has adjacent each end a cylindrical track link engaging portion and is relieved intermediate its ends. The cast iron liner serves as a bearing member to engage a pin or spindle on which the roller is mounted.

I propose to cast this roller in a continuous, uninterrupted sequence of steps, wherein a hard sand or permanent metal mold will be provided, the inner peripheral contour of which conforms to the desired outer peripheral contour of the steel mantle. This mold will be spun in a centrifugal casting spinner. A predetermined amount of molten steel will be poured into the mold and as the mold spins, preferably about a horizontal axis, centrifugal force will cause a uniform distribution of the molten steel about the inner periphery of the mold so that the molten steel will conform on its outer periphery to the pattern of the mold and will on its inner periphery be generally cylindrical.

After the steel has been poured into the mold and spun to produce the above mentioned result, molten iron will be poured into the mold, the mold continuing to spin and the molten iron will by centrifugal force be distributed as a hollow cylindrical or tubular member lining the steel mantle.

The iron will be poured into the mold against the steel only when the steel has cooled and solidified to a generally plastic condition. If the iron is poured while the steel is still liquid, there is danger of a general mixing of iron and steel in the mold which would result in losing the benefits of the steel mantle and the iron liner. If the iron is poured too late, the steel temperature will be so low that there is danger of failure of the heat bond between the iron and steel.

Because the mold is simple and there are no narrow passages through which the steel must travel and because the steel travels as it is distributed about the outer periphery of the mold under the influence of centrifugal force much greater than the force of gravity, the steel may be poured at relatively low temperatures, of course, it must be molten. This results in saving because the hotter the steel is the harder it is on the mold, because the lower the pouring temperature the less the melting cost and because after the steel has distributed itself about the periphery of the mold and commences to solidify the time at which the iron can be poured comes earlier in the cycle.

On the other hand, the iron is poured at higher than usual casting temperatures. This is important because while the steel must bave reached at least a plastic condition throughout its entire body before the iron is introduced, the temperature of the surface of the steel must be raised again above temperature of plasticity, by contact of the hot molten iron, in order to insure a fused or thermal bond. The timing of the pouring of the iron is also important because when the steel is first poured into the mold, air is expelled by the gases resultant from the pouring of the steel into the mold and the atmosphere is a reducing atmosphere, if too long a delay results the atmosphere may become oxidizing with air entering and this would cause the formation of scale on the surface of the steel. If the iron is poured soon enough so that the atmosphere in the mold is still a reducing atmosphere, then no scale formation results, the iron comes in direct contact with the steel surface, raises the temperature of that surface to the fusing point and an intimate fused bond results between the steel and iron.

The mold is closed at both ends except for two generally aligned apertures. One is the aperture through which the molten metal is poured, another the gas escape aperture through which the gases generated may continue to escape during the pouring operation. This is important because as the molten metal, whether steel or iron, tends to fill the mold, substantial gas pressure develops. That pressure can escape freely from the mold in a direction opposite to the entrance of the metal and so does not interfere with the pouring operation and pouring therefore may continue at a maximum rate during the time it is taking place.

The vibration inherent in any spinner, the impact of the molten iron, the scouring effect that may be produced as the molten iron is speeded up to the rate of rotation of the mold and shrinkage as the steel cools together will result in a multiplicity of irregularities in the contour of the fused iron and steel surfaces where they are bonded together by fusion or welding so that there results an intimate, fused or welded bond between the steel and iron, the bond being generally cylindrical but having a multitude of local variations from a true cylinder.

Sections cut from such a cylinder show in some instances a fairly level line of bonding between the iron and steel. In other instances, the section shows a wavy line of bond but in every case the sections which have been cut show a fused heat bond between the iron and the steel.

The coefficient of expansion of iron and steel varies slightly and after the roll has been taken from the mold and cooled, it is important that the varying expansion and contraction of the iron and steel do not overload or break down the bond between the iron and steel.

Examination of the sections above referred to disclose that on each side of the bonding or fusion line or surface, there is what might be called a twilight zone, the steel increasing somewhat in carbon content toward the bonding line, the iron decreasing somewhat in carbon content toward the bonding line so that in this so-to-speak twilight zone we have a metal partaking somewhat of the characteristics of iron and somewhat of the characteristics of steel. Thus in this twilight zone there is of necessity a progressive change in coefficient of expansion from iron to steel or vice versa. This twilight zone serves as an area wherein stresses resulting from expansion and contraction are gradually dissipated so that there is not placed upon the actual bond as a result of expansion and contraction, a load which it is unable to support.

The irregularities above referred to in the mating fused cylindrical surfaces of the iron and steel accomplish two things, to promote a stronger bond between the iron and steel. They increase to some extent the total superficial area where the bond is found and they also promote a mechanical interlock between the iron and steel and thus

tend to reinforce by mechanical means the fused bond resulting from the welding or fusing together of the iron and steel.

My invention is illustrated more or less diagrammatically in the accompanying drawing, wherein

Figure 1 is a longitudinal section through a roll cast according to my invention;

Figure 2 is a transverse section along the line 2—2 of Figure 1;

Figure 3 is an enlarged section in the plane of Figure 1 showing a generally smooth steel and iron bond line;

Figure 4 is a similar section showing a wavy or rough bond line.

Like parts are indicated by like characters throughout the specification and drawings.

1 is a chuck mounted on a spinner shaft 2, adapted to be rotated by motor means not here shown. A mold is adapted to be held within the chuck including a cylindrical portion 3, an inner apertured end plate 4, and an outer end plate 5, apertured at 6. Means for holding this mold in the chuck are not illustrated as they form no part of my invention.

7 is a steel mantle cast in the mold. It is flanged at each end as at 8. Immediately adjacent the two flanges it has at each end a cylindrical bearing ring 9 and is reduced in cross sectional area between the bearing rings. The end plates for the mold have bosses 10 as indicated to define for the ends of the steel portion of the roll, curved, flaring walls extending outwardly to the flanges and limiting the over all length of the cylindrical iron liner so as to provide a casting wherein the iron sleeve or liner is somewhat shorter than the steel mantle.

The apertured inner end plate 4, the aperture 12 being slightly smaller in diameter than the aperture 6, is in register with a discharge passage 13 extending through the shaft 2 whereby gases escaping from the mold may be discharged to the atmosphere. 14 is a pouring spout. It enters the mold through the aperture 6 and conducts molten metal from the ladle 15 through the end plate 5 to discharge it into the mold.

The mold is short so the molten metal will travel under the influence of centrifugal force clear in to the opposite end of the mold without interference.

The use and operation of my invention are as follows:

I have illustrated my invention as applied to a bearing roll especially adapted to track laying vehicles. However, my invention involving as it does the production by centrifugal casting of a bimetal hollow cylindrical object is not necessarily limited to the production of the particular type of rollers used to illustrate the invention. I have illustrated a device where the steel is on the outside and the iron is on the inside because that is what is needed in connection with the particular mechanical element produced. Under other circumstances the same casting method might produce a sleeve or cylindrical member where the iron is on the outside and the steel is on the inside or it might be used to produce an article where there are several spaced layers of iron and steel, each one cast within the previous layer.

It is highly desirable, in many cases absolutely essential, that the separate layers be continuously and positively bonded throughout their entire opposed areas to each other. Therefore, in order to accomplish this bond, the temperature of the iron and steel at and immediately adjacent to the bonding surface or zone must be high enough that the two metals will each be of sufficient plasticity to permit centrifugal force to hold them together until the fused bond is completed. The mass of the two metals must be such and the temperature of the two metals must be such that this fused bond will have time to form before the metals cool far enough down to become solidified and to permit of relative tensions and stresses resultant from difference of coefficients of expansion and contraction under temperature change.

The essential thing, of course, is that the fused bond

be formed and that there be such a character of metal on both sides of the bond that expansion and contraction resultant from change in temperature will not break that bond. The desired temperature can be brought about in a number of different ways. The steel can be hotter than the iron or the iron can be hotter than the steel or they can both be of the same temperature provided only the resultant temperature of the metal at and on both sides of the bonding zone is high enough to permit the formation of the fused bond.

As illustrated, the steel and iron are coextensive from end to end of the roller. If less steel were poured, the steel could equally well be found only at the two ends of the roller, in which case the iron liner would extend from end to end and the mantle would be a two part mantle, one part at each end of the iron liner. However, the principle of operation would be identical.

The mold is a simple, generally cylindrical mold. As pouring continues, a substantial proportion of the mold volume is filled with the metal. Thus the air or gas capacity of the mold decreases rapidly as the metal pours in. This together with the generation of gas as a result of the entrance of the metal into the mold builds up substantial gas pressures. The pouring gate at one end of the mold fills substantially all of the mold opening and therefore the mold is vented at the other end to permit the escape of gas from the mold without interfering with the pouring action. Without that vent the pouring rate would be of necessity lower than is desirable.

As the molten steel enters the rotating or spinning mold, it is picked up by the mold and caused to flow by centrifugal force outwardly toward the entire peripheral mold area. The centrifugal force is much more powerful than the force of gravity and so the steel even at relatively low pouring temperatures and therefore of relatively high viscosity is by centrifugal force positively distributed around the outer periphery of the mold.

The mold continues to rotate as the steel solidifies and it is important to allow this action to continue until the steel temperature has dropped below the melting point to a point of distinct plasticity. Then and only then is the iron poured into the mold. If the steel were still liquid when the iron was poured in, steel particles or steel masses might be washed or scoured off the body of the iron and would migrate as steel masses up into the iron, thus losing the sharply defined different characteristics of the iron and the steel. If the delay were too great before the iron was poured into the mold, scale might have time to form on the surface of the steel and thus interfere with the formation of an integral fused bond between the iron and steel.

As the steel is poured into the mold, the air in the mold is purged and expelled by the generation of gases resulting from the steel and the contact between the steel and the mold especially when the mold is a sand mold but after pouring has ceased, the gas pressures can drop and there is danger of air entering into the mold and changing the atmosphere from reducing to oxidizing. There is, however, a time interval during which these gases continue to be expelled from the mold and if the steel is poured in before this movement of gas from the mold has ceased, then there is no danger of oxidation. To be sure, a flux might precede the steel into the mold to unite with the oxides to form slag lighter than the iron which would float by centrifugal force to the inner periphery of the iron.

As soon as the steel has reached the optimum temperature for plasticity and the iron has been poured in and been distributed by centrifugal force about the outer periphery of the mold surface defined by the plastic steel since the iron is at superheated temperature, it instantly raises the temperature of the surface of the steel above the melting point, thus permitting the formation of a fused thermal bond between the iron and the

steel without migration of steel as steel through the molten iron. There is, of course, under these circumstances some migration of carbon so that a twilight zone is formed between the iron and steel where the carbon from the iron migrates into the steel and is replaced by ferrite but this twilight zone of migration is very slight compared to the total thickness of the casting and the result is that the outer mantle is of steel and the inner lining is of cast iron.

After the iron has solidified and care must be taken to insure that spinning of the casting continues until both the iron and steel have both solidified so no bleeders are formed, then rotation may be stopped, the casting expelled from the mold and cooled in any desired way. Under some circumstances cooling will take place by the introduction of mist or spray into the interior of the mold or by the introduction of air or other coolant. This will have no effect on the integrity of the casting because it will contact only the periphery of the iron liner which will be machined away any way when the roller is manufactured for use and because there is an intimate fused heat bond formed between the iron and steel and because of the twilight zone of intermixed iron and steel on both sides of that bond, relative expansion and contraction of the two metals resulting in change in temperature does not break the bond between them.

While in general it is best to pour the steel at as low temperature as possible to insure proper pouring and proper centrifugal distribution and while it is best to pour the iron at relatively high temperature to insure the formation of a fused bond, I have found that as a general rule, it is best to pour the steel at a temperature in the order of 2900° F. and the iron at a temperature in the order of 2850° F.

I have used the terms "plastic" and "mushy" in describing the condition of the steel at the time the iron is poured. It should be emphasized that this requirement is best met when the steel is no longer liquid or fluid except perhaps just at the surface but before it has reached the completely solid state. In other words, it

is the condition characteristic of metal when forged by the blacksmith on the forge. Under these circumstances, an effective heat bond or metallurgical bond may best be obtained.

I claim:

The method of centrifugally casting bimetallic cylinders of ferrous metal such as steel and cast iron which includes rotating a generally cylindrical metal forming zone about its longitudinal axis, the zone being vented at both ends in general alignment with the axis of rotation, pouring the first molten metal into the zone through the vent at one end, accumulating the gases escaping from the casting sufficiently to generate a pressure in the zone sufficient to expel all the air therefrom and maintain therein a reducing atmosphere, continuing the rotation of the zone until the metal has cooled so that the inner periphery of the cylindrical surface, resulting from the rotation, is mushy and plastic but neither liquid nor solid, pouring the second metal into the zone at a temperature above the temperature of the surface of the first metal, continuing rotation of the zone and the metal therein contained until the second metal has formed a cylindrical shell covering the first metal and both metals have solidified and a thermal heat bond has been formed between them.

References Cited in the file of this patent

UNITED STATES PATENTS

1,377,372	Thompson	May 10, 1921
1,466,826	Gordon	Sept. 4, 1923
1,514,129	Clark	Nov. 4, 1924
1,532,690	Flaherty	Apr. 7, 1925
1,615,877	Knocke	Feb. 1, 1927
1,707,117	Foster	Mar. 26, 1929
1,733,661	Gillhausen	Oct. 29, 1929
1,943,720	Campbell	Jan. 16, 1934
2,008,196	Weber	July 16, 1935
2,087,347	Larsen	July 20, 1937
2,178,163	Davidson	Oct. 31, 1939
2,265,740	Morgan	Dec. 9, 1941